Phytoremediation Along the Indiana Harbor Canal

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Canal system overview.

Sheen on Federal IHC facing east

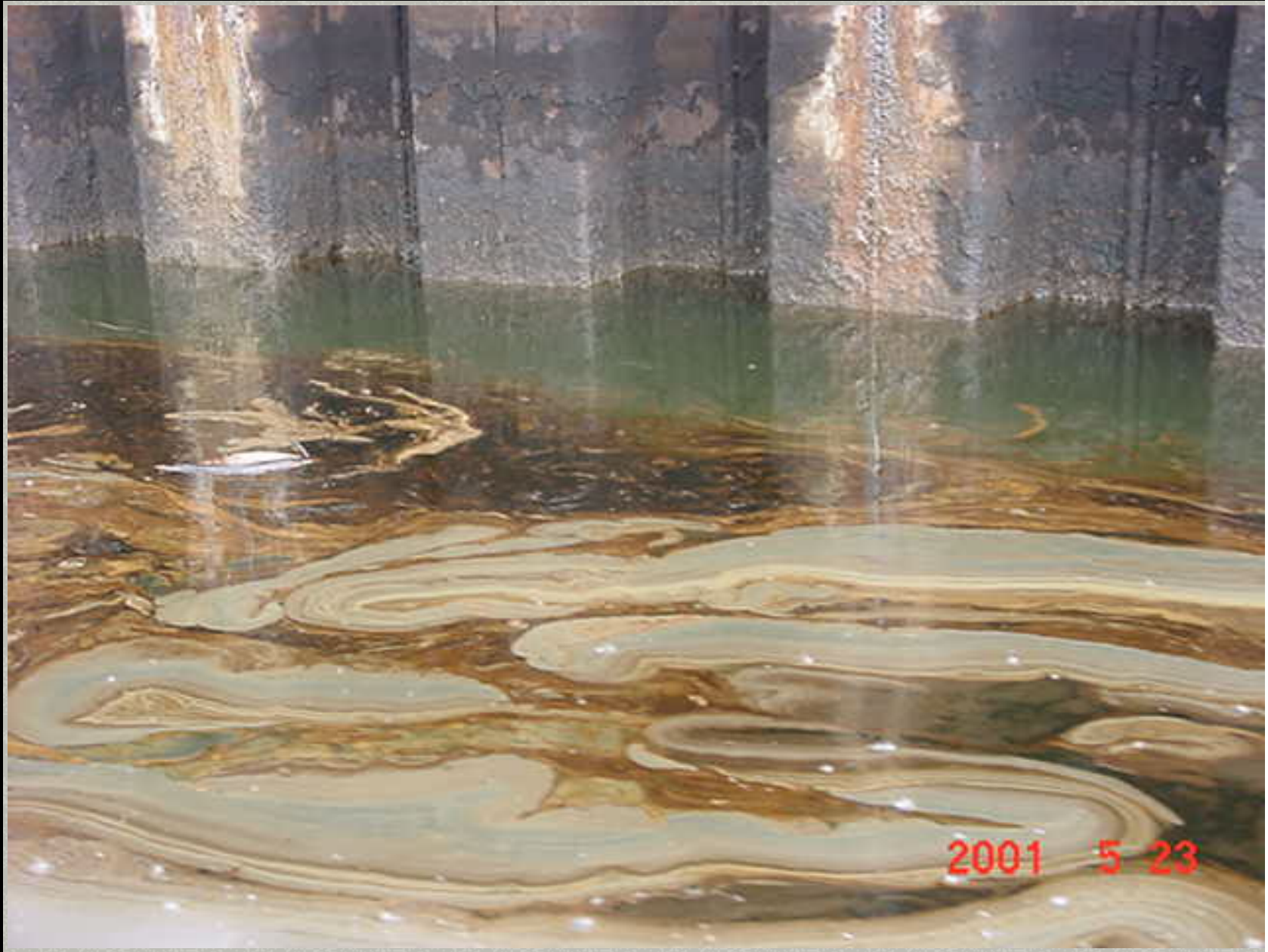
Oiled Turtle, IHC

This is the second largest flyway in the continental U.S.

Many migratory birds stop off at the tip of Lake Michigan and this is what they find.

Great White Egret Pair on Bank of IHC

There is still substantial contamination coming from ground water



More Mousse

There is also unaccounted for oil.

- Sediments?
- Re-oiling from the Shoreline?
- Groundwater?
- Illegal dumping?

Dead Carp, Heavy Sheen on Oiled Canal Bank

Overall Goals for the Canal

- Containment or stabilization of oil
- Oil removal through many means including degradation
- Establishment or restoration of habitat

Programs to Reach Goals

- Enforcement (EPA R5)
- Natural Resource Damage Assessment
  (USF&WS and Indiana Dept. of Env. Management)
- Clean-up of hot spots (EPA R5)
- Bioremediation (EPA ORD)
- Phytoremediation
  - **Survivability (EPA ORD)**
  - **Field studies (Sand Creek Consultants, Inc.)**
  - **Green house studies (Purdue University)**

Planting History at IH

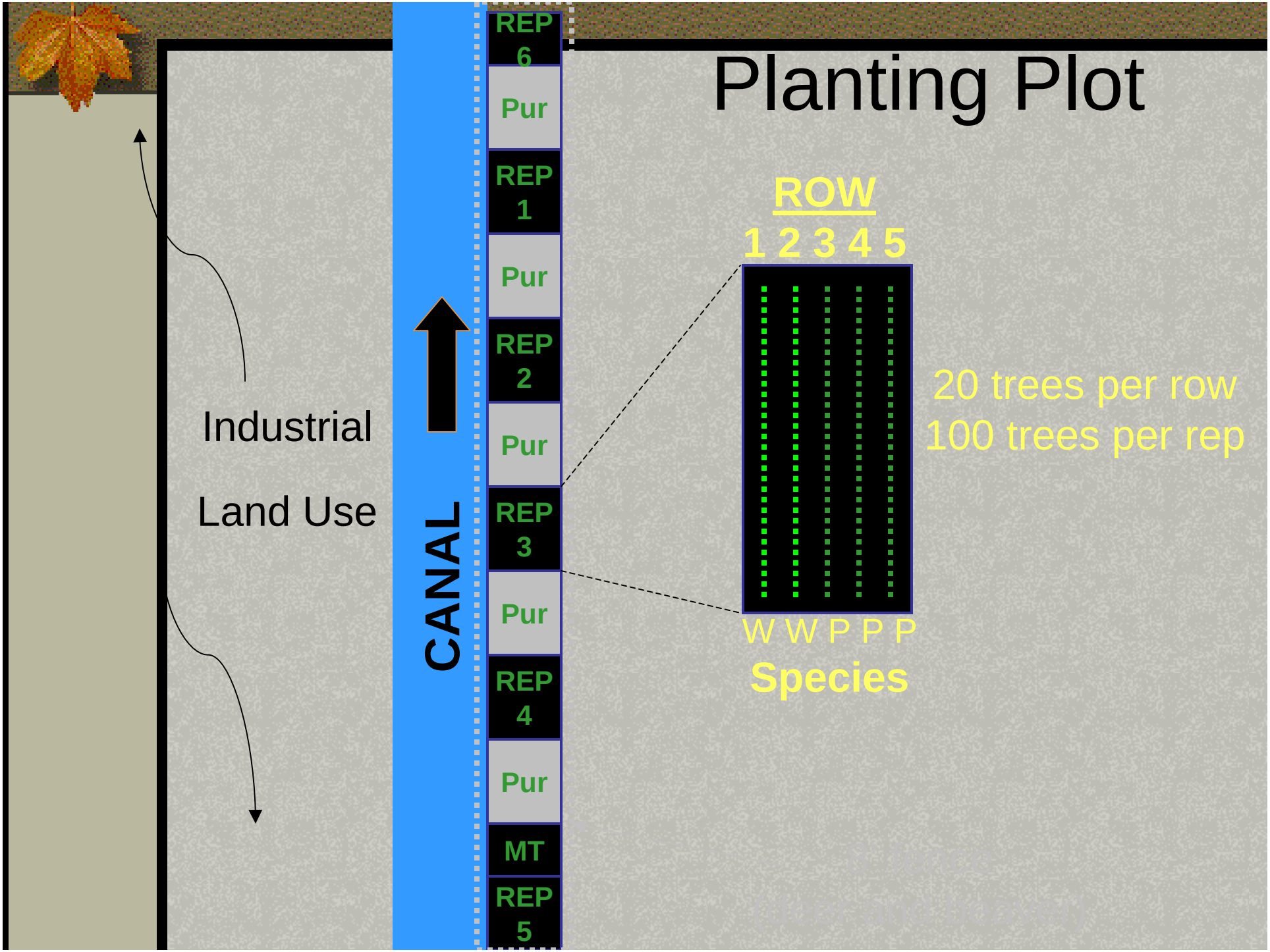
- Recon and sampling Dec. 2001
- Pot studies for plant selection and planting strategy 1/02
- Initial field planting Spring 02
- Second field planting Spring 03

Reconnaissance

We found:
Layers
Bare stretches of beach
Arrowhead, cattails, phragmites
15+% TPH

Description of Study

- Phytoremediation is being considered for full-scale Indiana Harbor clean-up.
- Field and greenhouse studies were funded for feasibility investigation.
- Target plants were switchgrass (*Panicum virgatum* L.), poplar (*Populus sargentii)*, carex (*Carex stricta)*, Eastern gamagrass (*Tripsacum dactyloides)*, willow (*Salix exigua)*, and arrowhead *(Sagitaria latifolia)*.
- Plant growth, biomass, microbial populations, and contaminant concentrations were monitored.
- Field plots were established in the June of 2002 and monitored until September, 2003.
- The greenhouse study was conducted from September, 2002 to October, 2003.


Planting Plot
REP 6
Pur
REP 1
Pur
REP 2
Pur
REP 3
Pur
REP 4
Pur
MT
REP 5
CANAL
Industrial
Land Use
ROW
1 2 3 4 5
W W P P P
Species
20 trees per row
100 trees per rep

Planting: Poplar and Willow Cuttings

- 10” cuttings in 2002
- 36” cuttings in 2003

Oct 25, 2002 (21 weeks)

Qualitative Root Evaluation

Dense root mass concentrated in oily soil horizon

Qualitative Root Evaluation

Indiana Harbor Field Site - 2002

2003 Planting

36” cuttings
No mulch,
No holes,
No fence
Slow release fertilizer
½ mile of canal bank

Purdue University Plot Plan

Gate

C	S	U	E
U	E	S	C

Plot A

E	U	C	S
S	C	E	U

Plot B

S	C	E	U
C	U	S	E

Plot C

U	S	E	C
E	U	C	S

Plot D

Canal

U = Unvegetated
S = Switchgrass
E = Eastern gamagrass
C = *Carex stricta*

Field Site – Initial Planting

Indiana Harbor Greenhouse Design

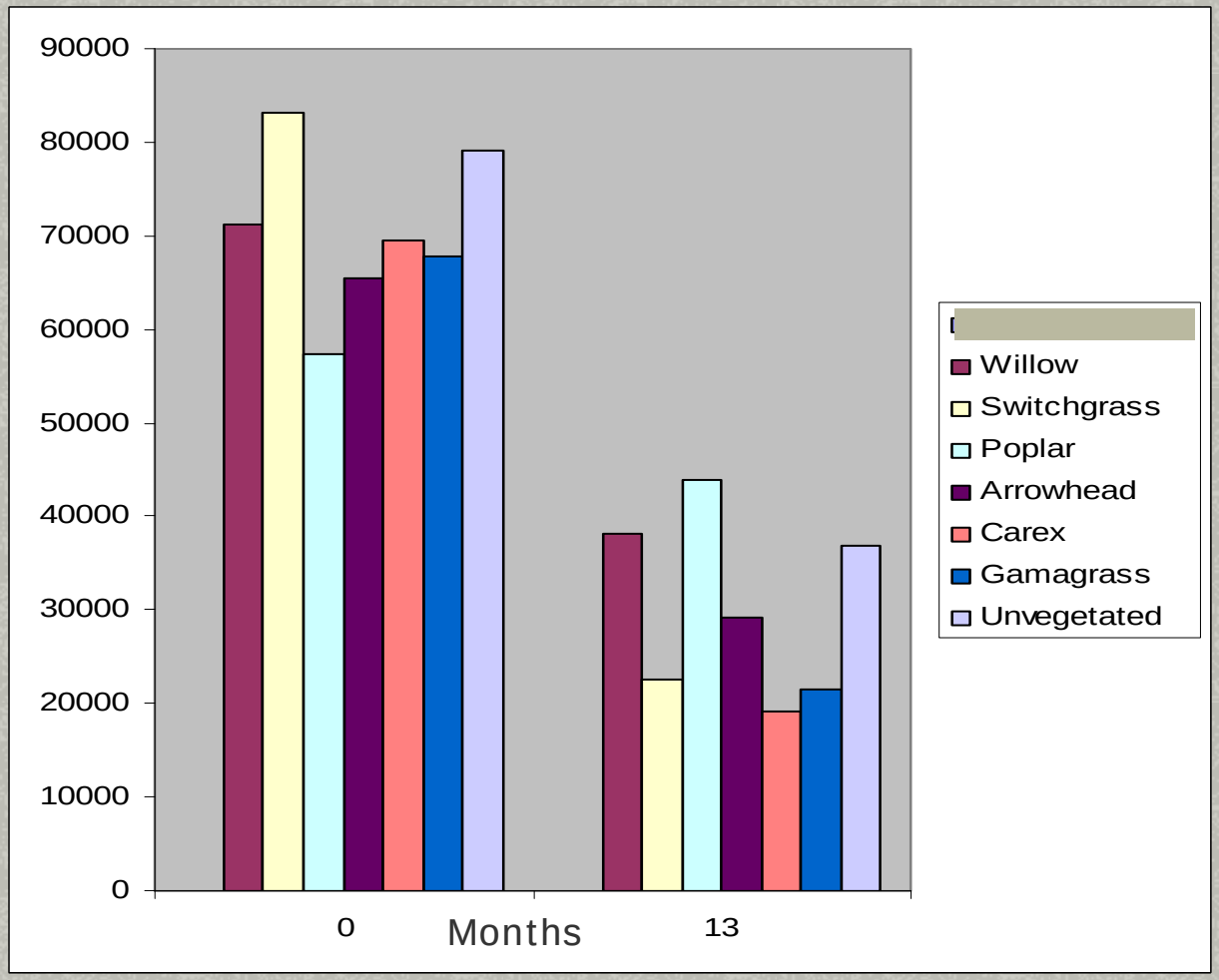
	U		S				P		U				A		W				S		A	
P		C		E		W		C		E		S		E		C		U		W		E
	W		A				A		S				P		U				C		P	

Rep 1 Rep. 2 Rep. 3 Rep. 4

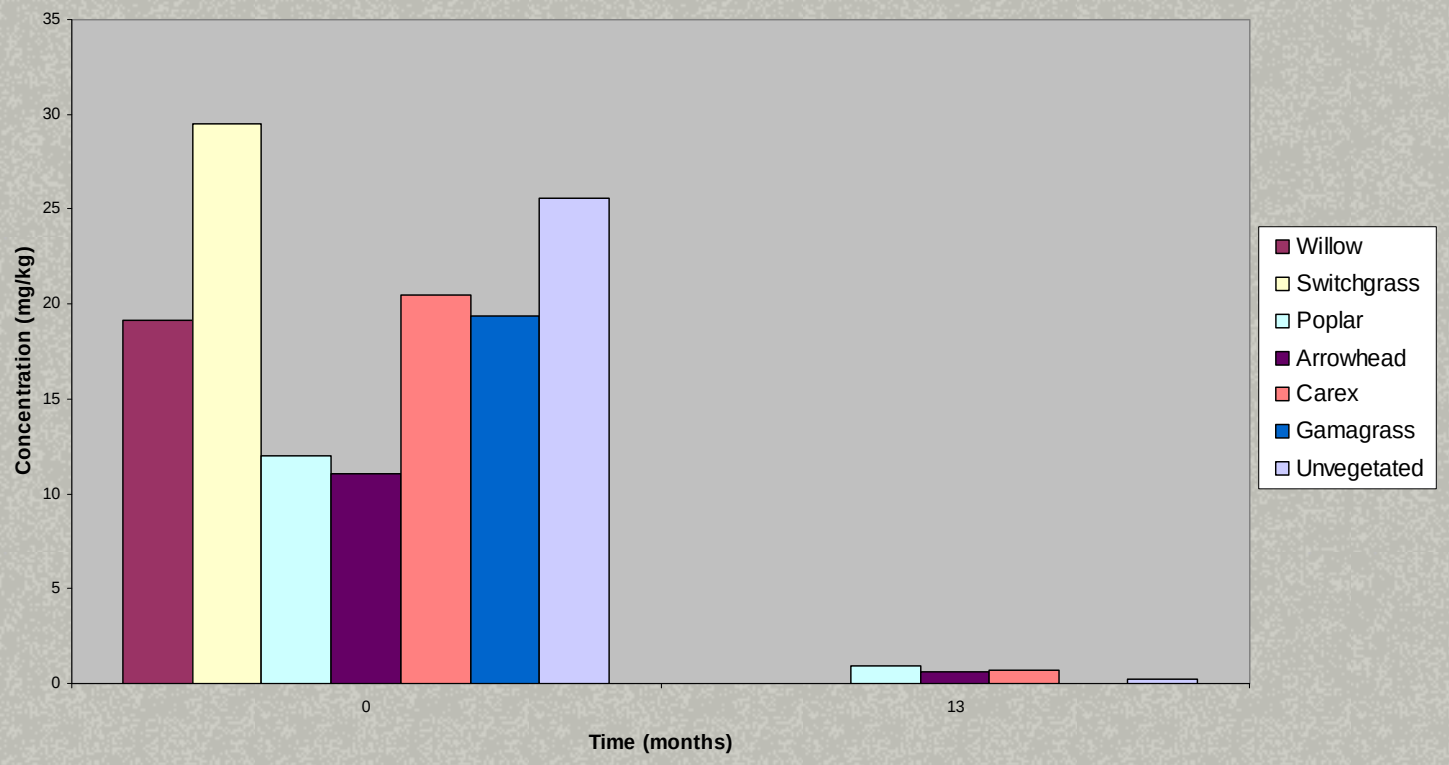
U=Unvegetated Control
S=Switchgrass (*Panicum virgatum* L.)
P=Poplar (*Populus sargentii)*
C=Carex (*Carex stricta)*
E=Eastern Gamagrass (*Tripsacum dactyloides)*
W=Willow (*Salix exigua)*
A=Arrowhead (*Sagittaria latifolia)*

Greenhouse Study – Eastern Gama Grass

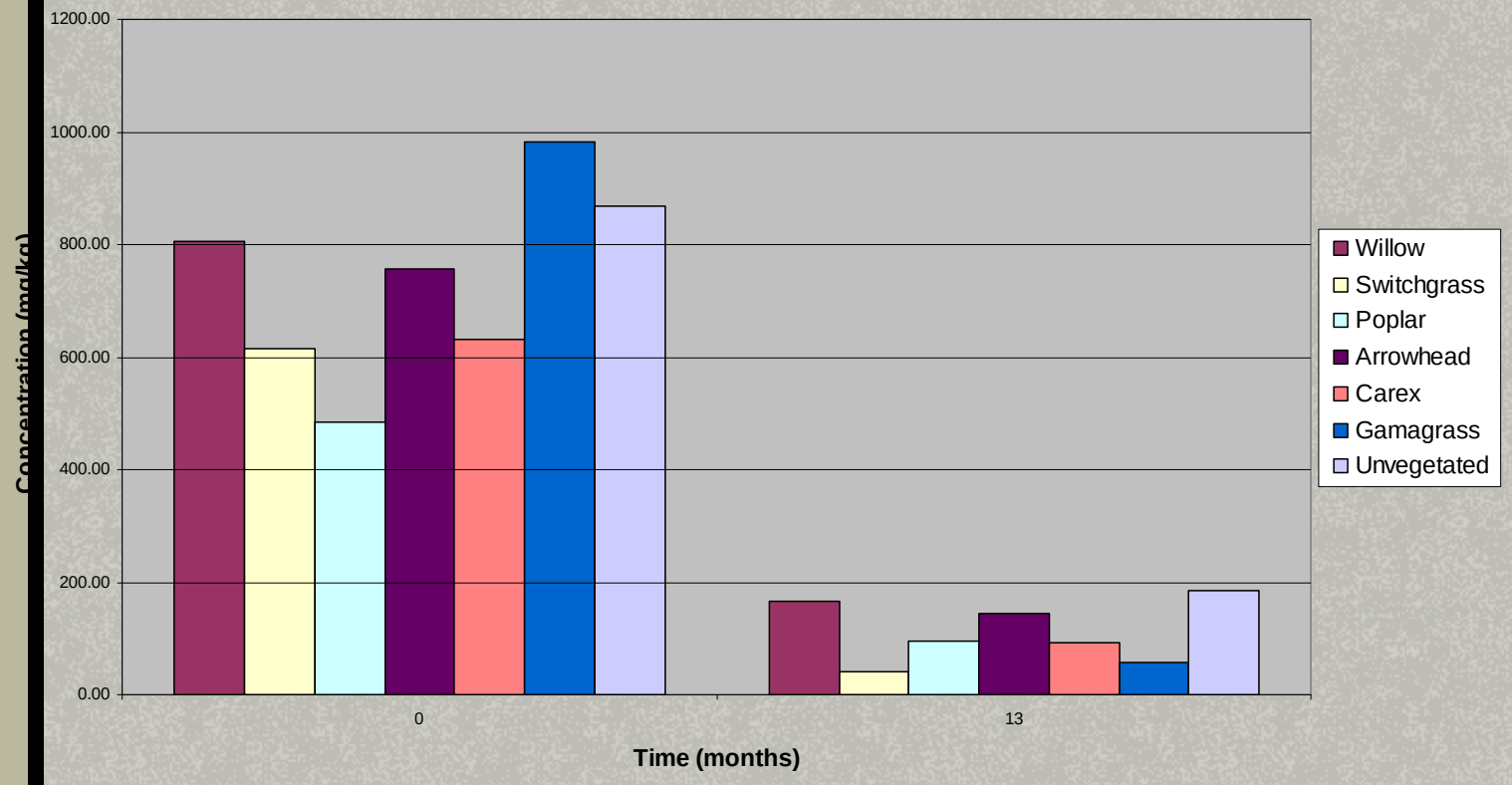
Greenhouse Study – TPH Analysis



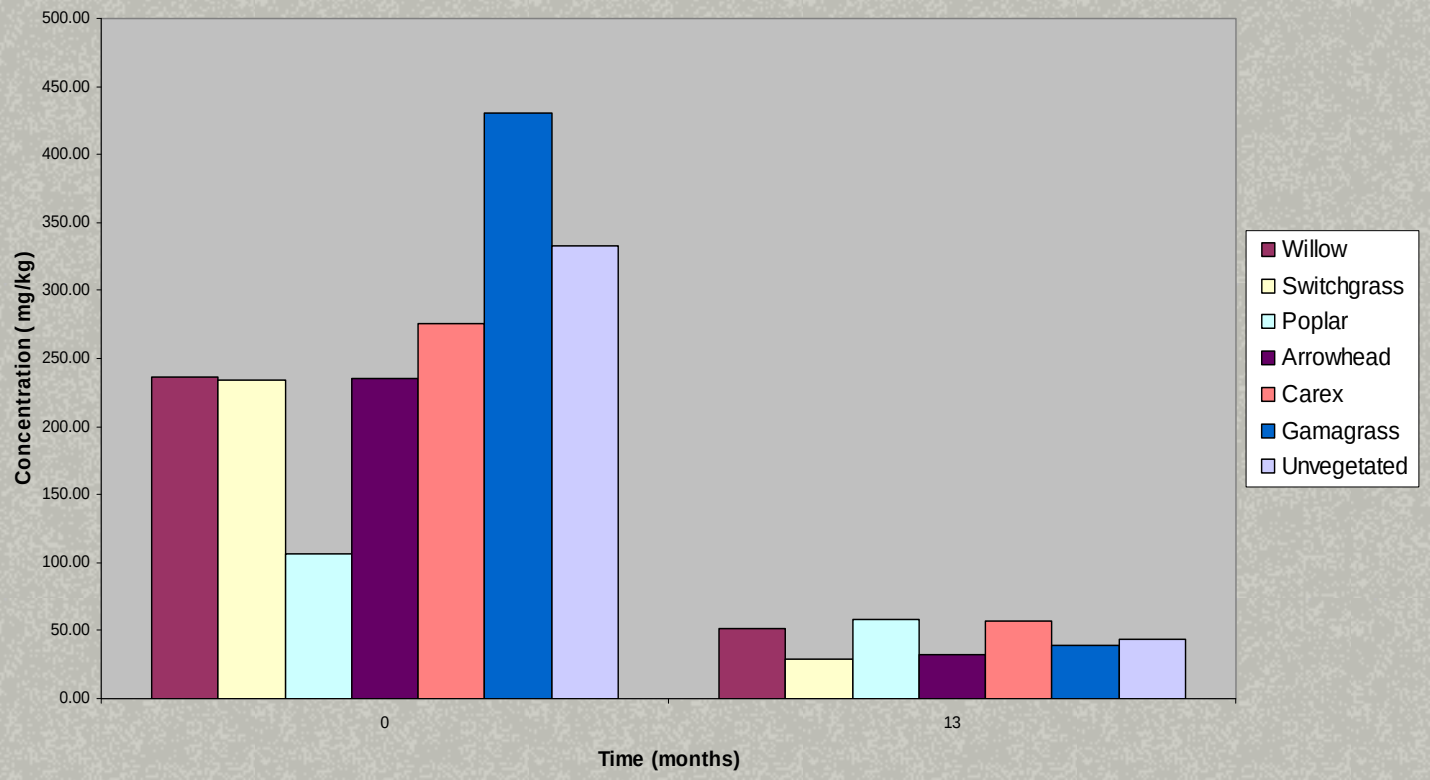
Greenhouse Study – PAH Analysis (Anthracene)



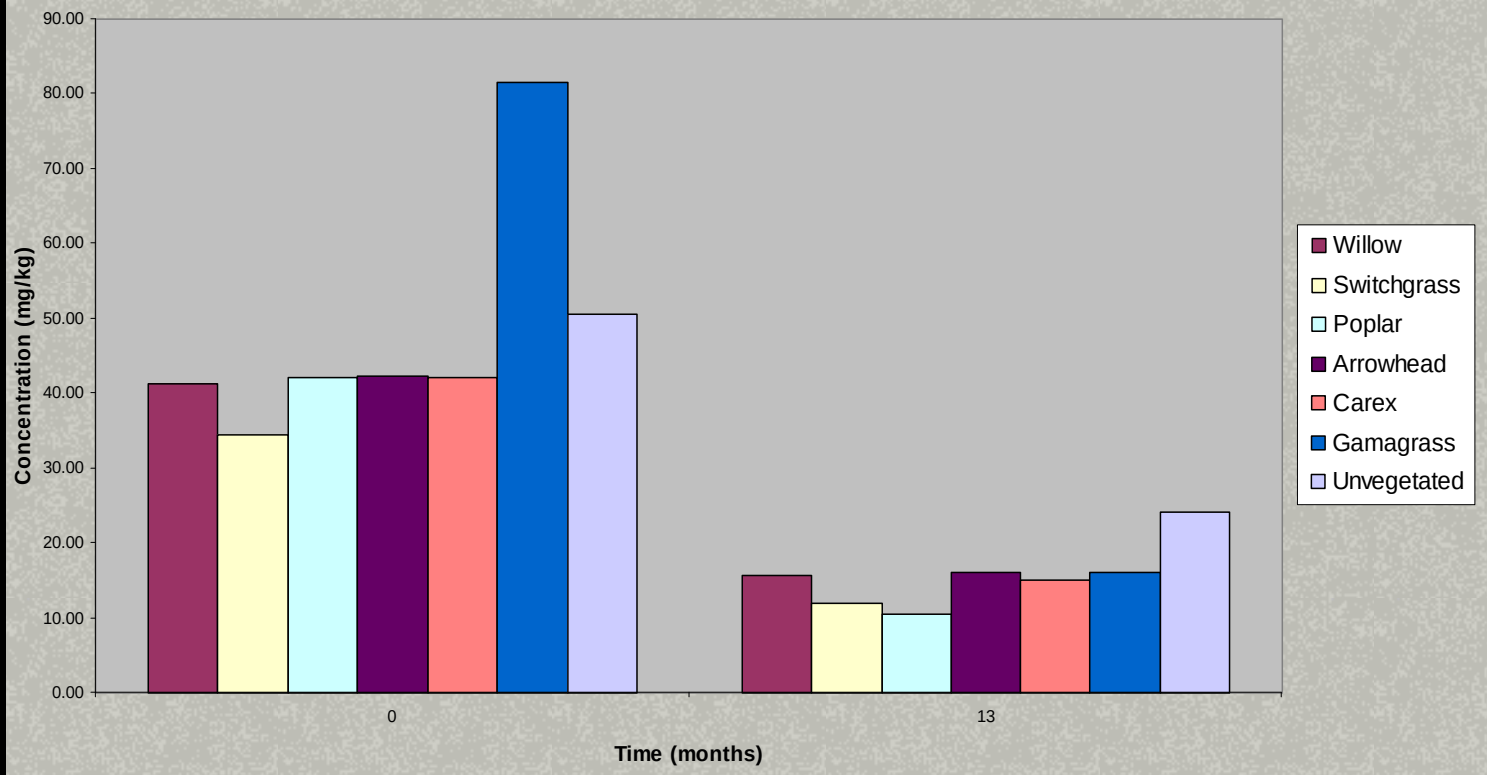
Greenhouse Study – PAH Analysis (Pyrene)



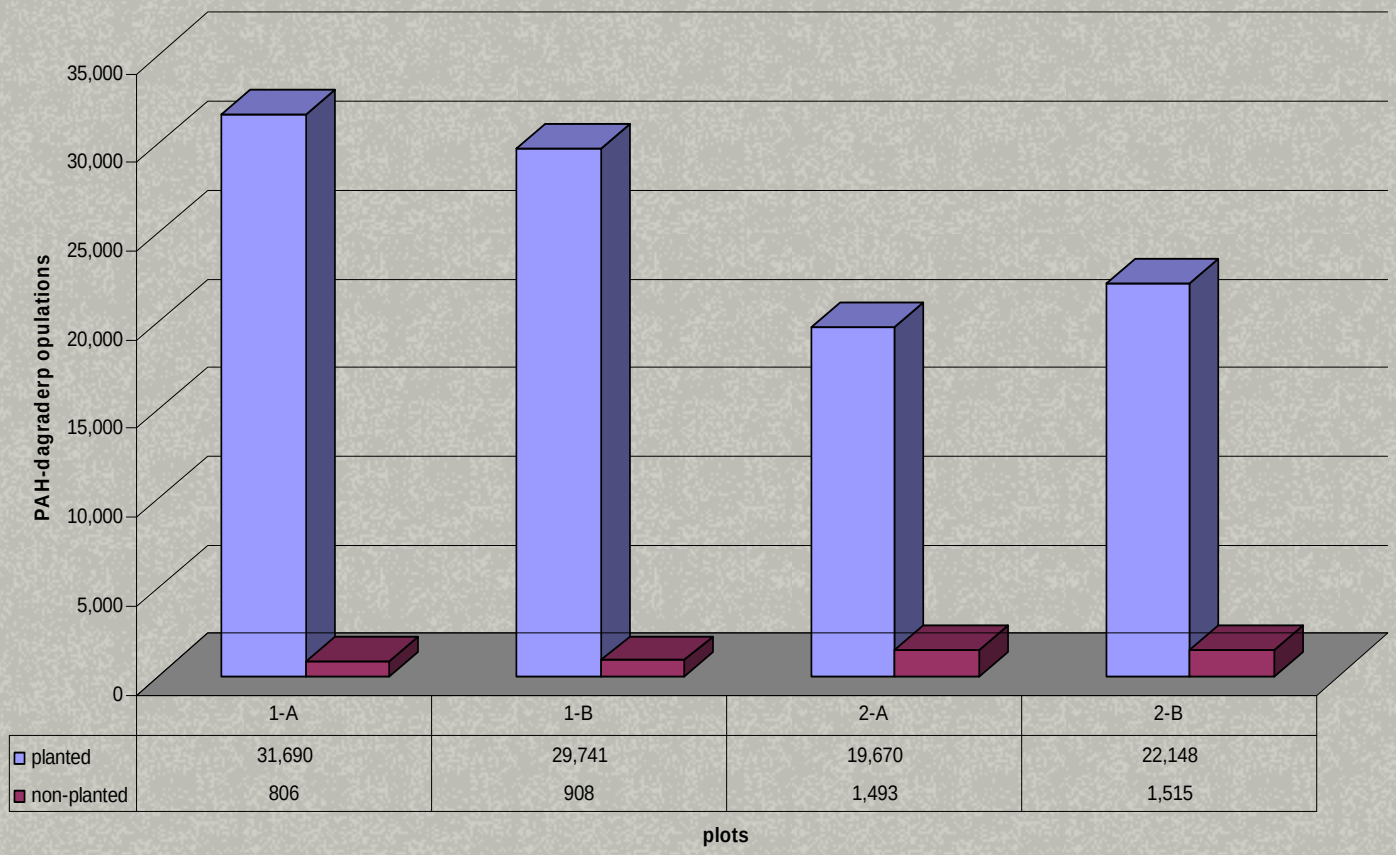
Greenhouse Study – PAH Analysis (Chrysene)



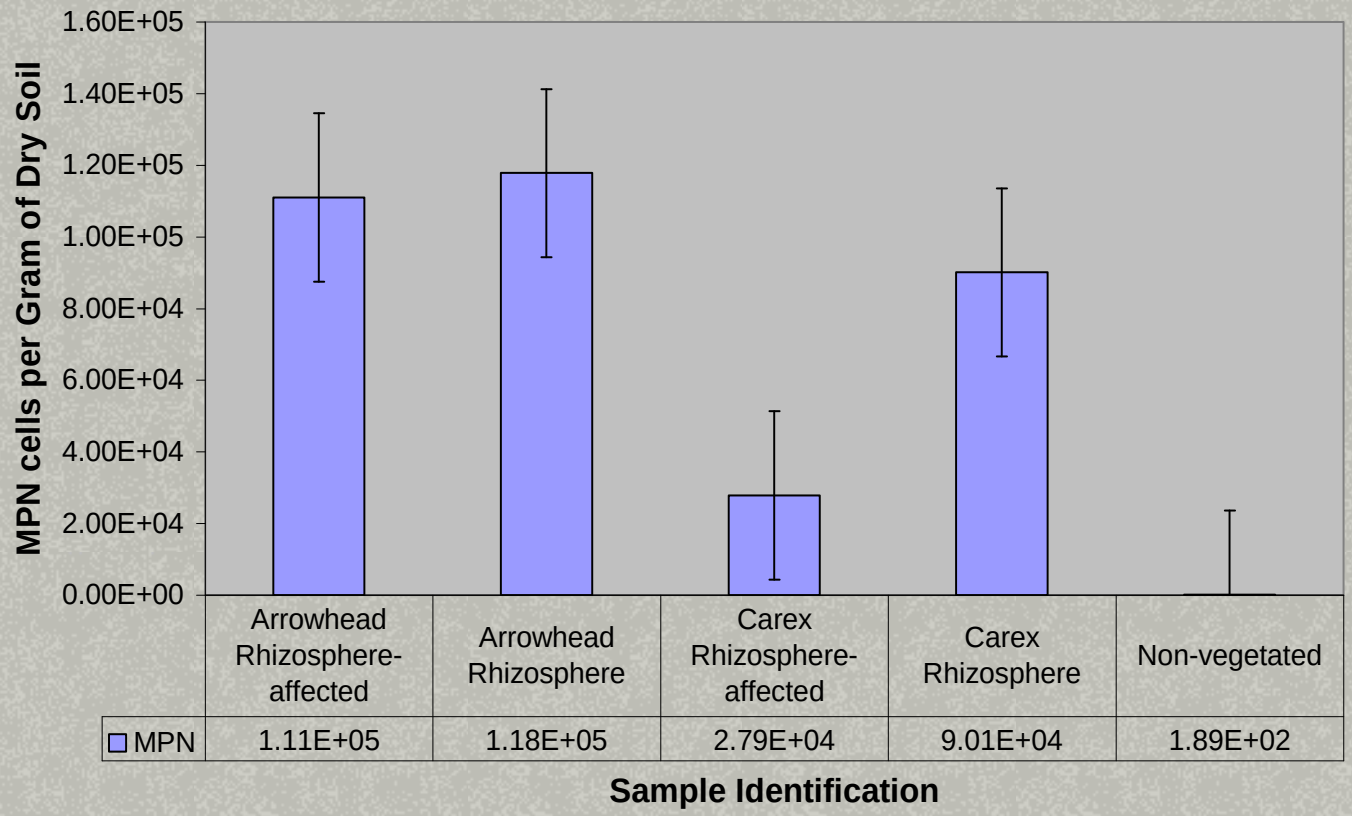
Greenhouse Study – PAH Analysis (Benzo[a]pyrene)



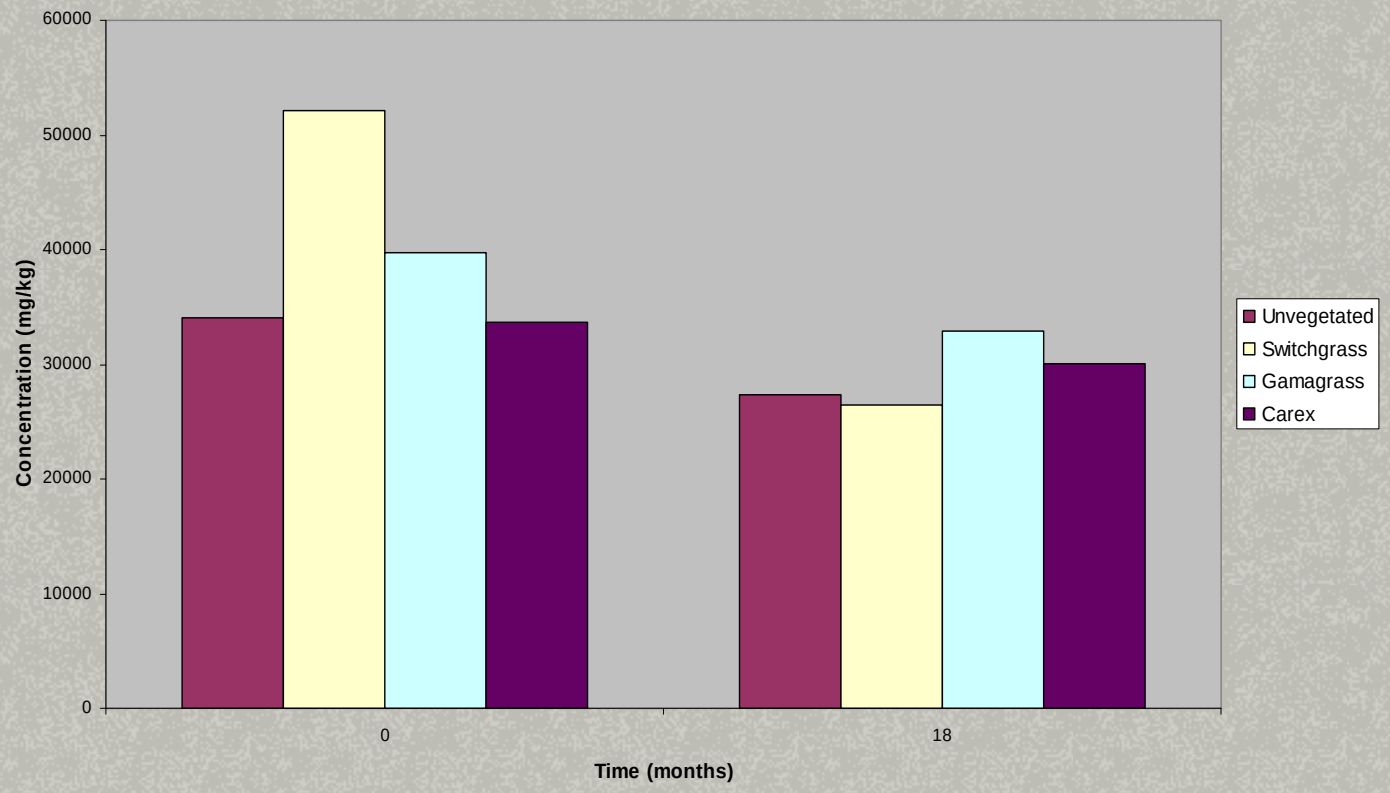
Field Site – PAH Degraders by MPN (August, 2002)



Field Site – PAH degaders (MPN)



Field Site – Average TPH Analysis



Conclusions

- The PAH-degraders are approximately 2–5 orders of magnitude greater in the rhizosphere and rhizosphere-influenced soil compared to non-vegetated soil.
- Molecular microbiological techniques indicate that organisms present in the arrowhead rhizosphere have significant PAH degradation ability.
- In the greenhouse, the plant root interaction with the soil resulted the following trend: switchgrass>Carex>gama>grass>poplar>willow.
- Arrowhead was difficult to grow in the greenhouse due to water requirements, limiting the assessment time after establishment.

Conclusions

- In the field, Eastern gama grass had the highest overall shoot biomass of the three plant treatments.
- Switchgrass had the highest percent coverage in the plots further away from the canal and Carex had the highest percent coverage in the plots closer to the canal.
- In the field study, Carex and switchgrass were the best performers in terms of TPH degradation, and were effective for several PAHs.
- In the greenhouse study, switchgrass, arrowhead, Carex, and gamagrass were the best performers in terms of TPH degradation, and were effective for several PAHs.

Conclusions

- Each type of plant works in a different micro environment
- Trees surrounded by grass limit beaver predation, increase hydrologic control, work on oiled ground water
- Grasses work in top 2-3 feet
- Arrowhead works at waters edge
- Varied planting may work best

Conclusions

- Possible to revegetate areas, will decrease sheen, re-oiling canal
- Beavers will slow tree growth (40% in ‘03)
- Restoration will work slowly but cheaply

July 2003